

IUGG General Assembly, Montreal, Canada – July 8-18, 2019

The impact of jointly determining TRF and CRF on the EOP

Benedikt Soja*, Richard Gross, Claudio Abbondanza, T. Mike Chin, Michael Heflin,
Jay Parker, and Xiaoping Wu

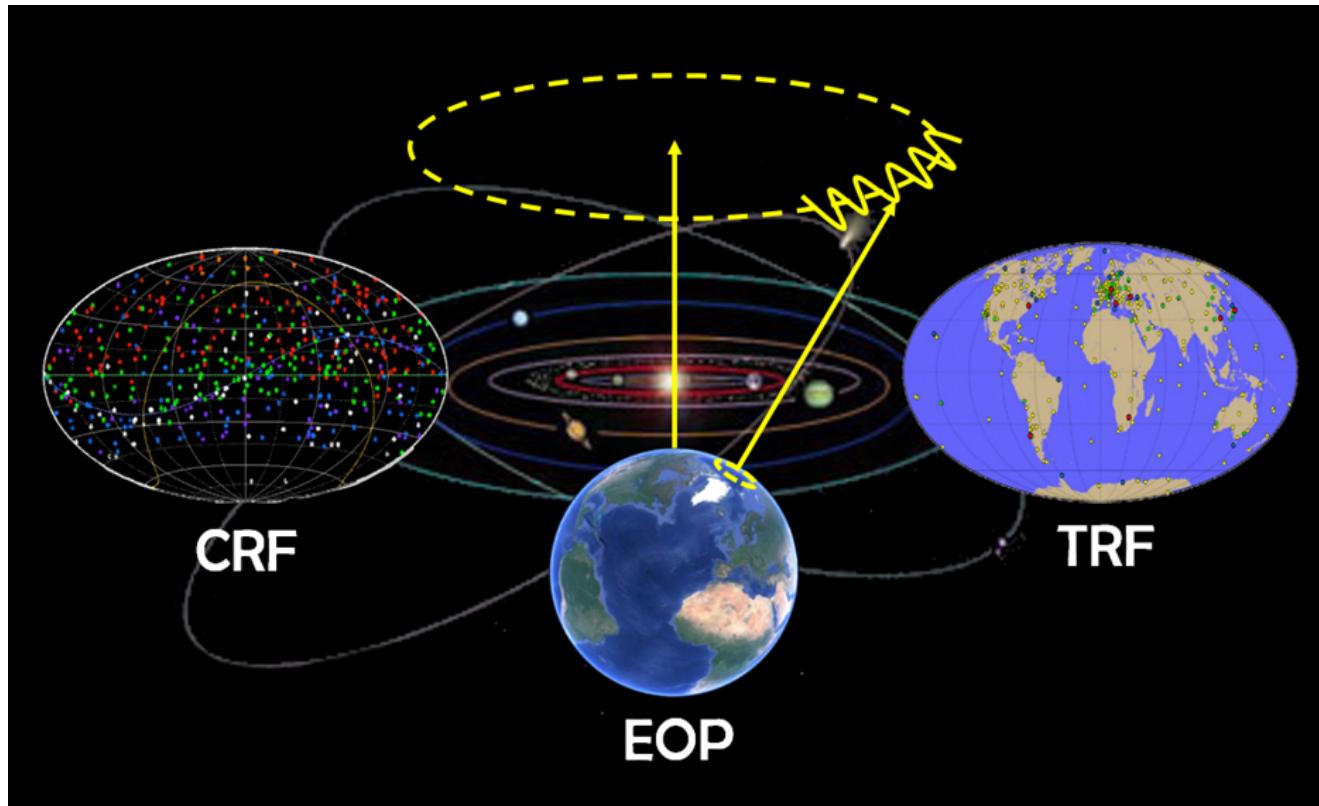
Jet Propulsion Laboratory, California Institute of
Technology, Pasadena, CA, United States of America

* bsoja@jpl.nasa.gov



Jet Propulsion Laboratory
California Institute of Technology

Introduction

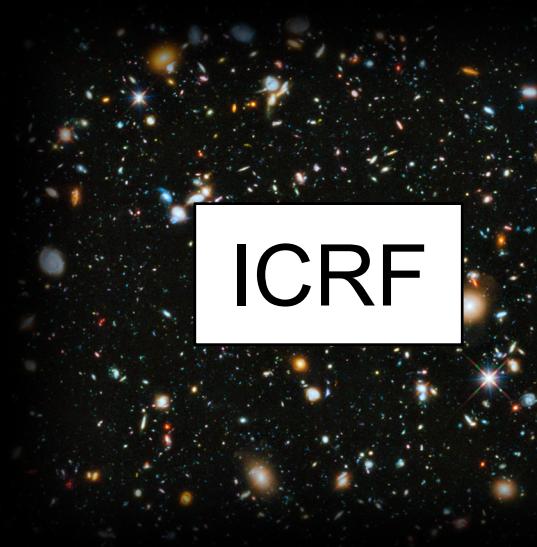


Inconsistencies between TRF and CRF



ITRF

different inputs
multi-technique vs VLBI



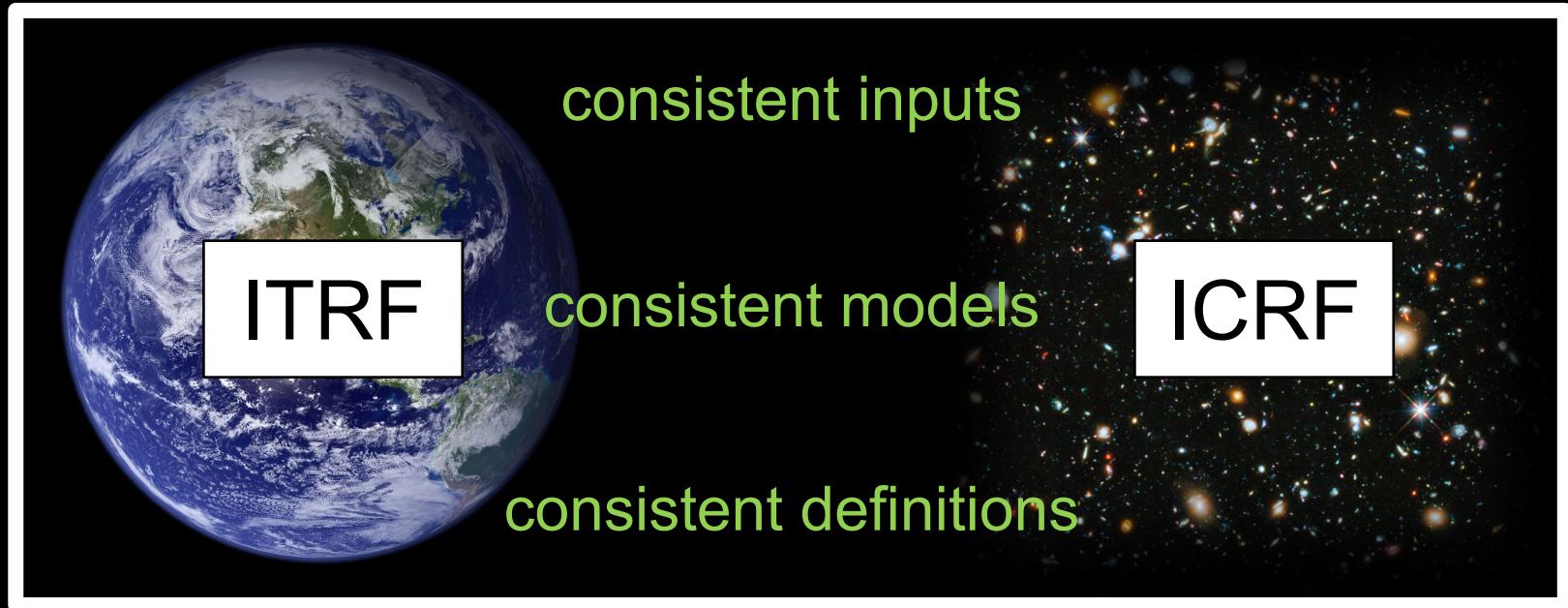
ICRF

different models
atmospheric loading

different definitions
scale

EOP are not the same for ITRF and ICRF

Joint determination TRF and CRF



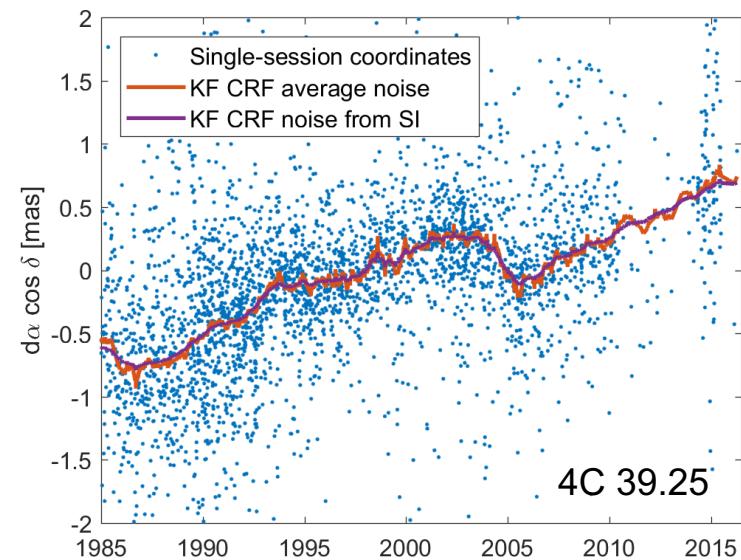
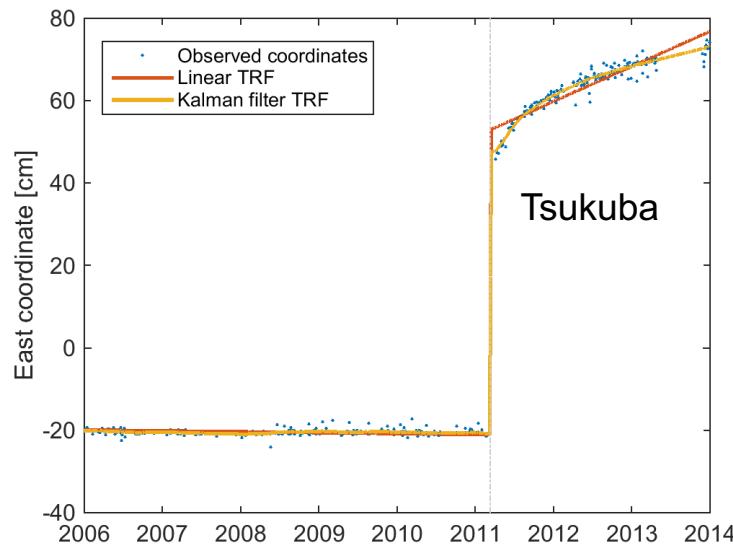
EOP are consistent with ITRF and ICRF

Overview

- Computation of **joint TRF and CRF** solutions based on
 - VLBI data only
 - Combination of VLBI, GNSS, SLR, and DORIS
- What is the **impact on the EOP?**
 - Comparisons to external EOP time series

Time series approach to TRF and CRF

- Reference frames defined by coordinate time series
- Software SREF based on square-root information filter
- Coordinate changes treated as stochastic processes
- Process noise based on physical processes
 - Geophysical loading for TRF, source structure for CRF



Methodology

- Connection between TRF and CRF:
EOP related to terrestrial (R_{xyz}) and celestial (A_{123}) rotations

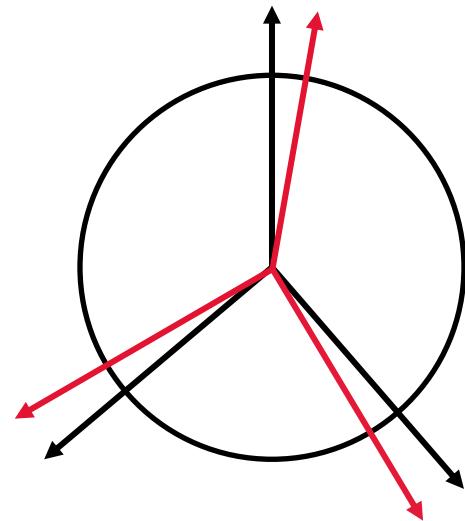
$$x_{p,t}^{obs} = x_{p,t}^{est} + R_{y,t}$$

$$y_{p,t}^{obs} = y_{p,t}^{est} + R_{x,t}$$

$$UT_t^{obs} = UT_t^{est} - R_{z,t} \cdot r' + A_{3,t} \cdot r'$$

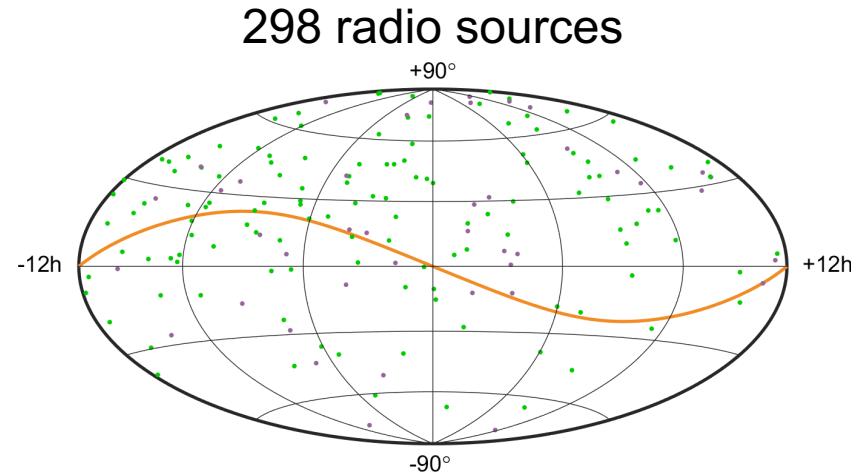
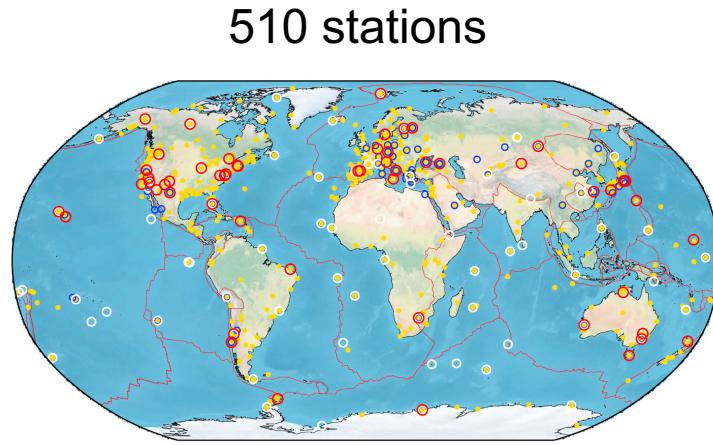
$$dX_t^{obs} = dX_t^{est} + A_{2,t}$$

$$dY_t^{obs} = dY_t^{est} + A_{1,t}$$



Input data

- JTRF2014 reduced network for GNSS, SLR, and DORIS
- GSFC operational solution (*gsf2016a*) for VLBI
 - Including radio source coordinates
- Time span 2000.0 – 2010.0



TRF transformation

Coordinate time
series averaged over
whole time span

- Helmert transformation w.r.t. ITRF2014

[mm]	Tx	Ty	Tz	λ	Rx	Ry	Rz
VLBI offset 2010	-0.15	1.06	-5.82	3.20	-4.08	1.78	-1.90
VLBI rate [/yr]	-0.09	0.03	-0.51	0.15	0.28	-0.00	-0.15
Comb offset 2010	-0.41	0.40	0.11	1.88	-1.84	1.56	0.24
Comb rate [/yr]	-0.18	0.72	0.40	0.45	0.13	-0.33	-0.03

- Translations, scale, and rotations closer to ITRF2014 for combined solution

CRF transformation

Coordinate time series averaged over whole time span

- Celestial transformation using vector spherical harmonics up to degree 2 w.r.t. ICRF3
 - Degree 1 terms

[mas]	A1	A2	A3	D1	D2	D3
VLBI	-0.389	0.004	0.077	0.026	0.045	-0.299
Comb	-0.392	0.006	0.076	0.026	0.045	-0.299

- Formal errors about 0.1 mas → insignificant differences

Earth orientation parameters

Comparison of EOP time series from

- VLBI input data
- VLBI-only TRF/CRF solution
- Combination TRF/CRF solution

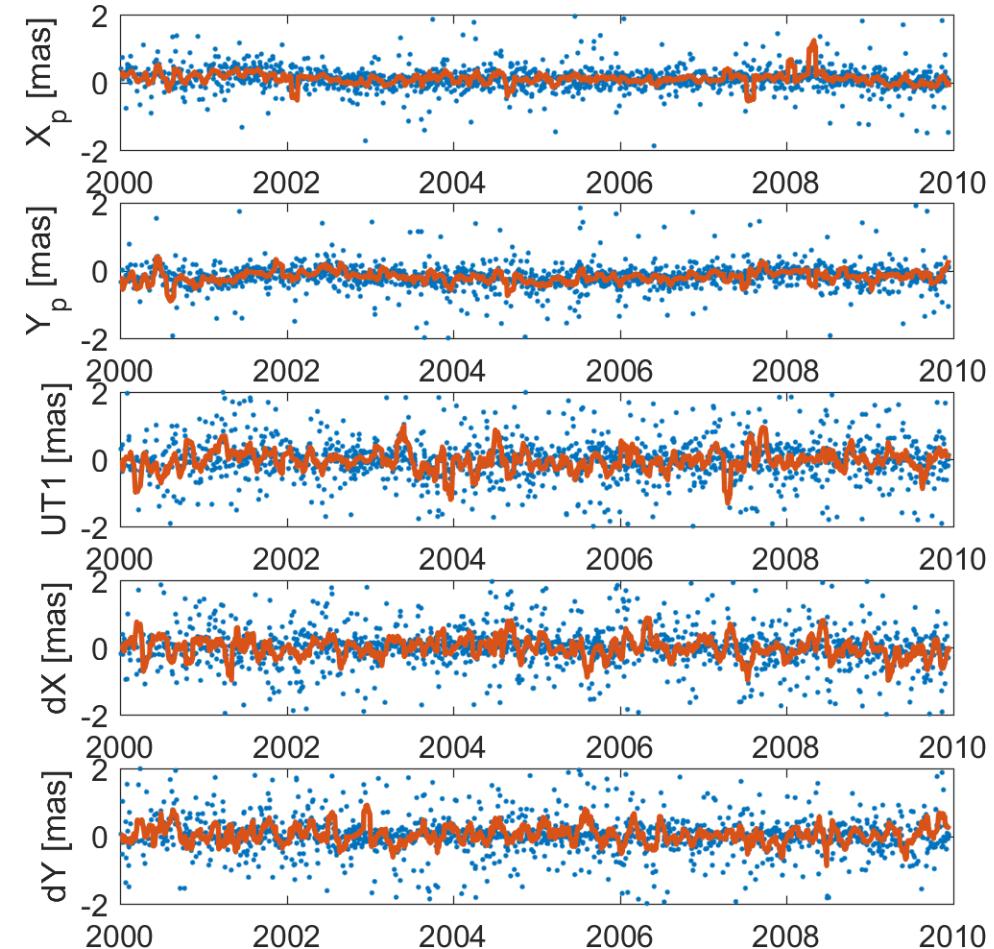
with external EOP time series:

- IERS 14 C04
- Not shown here:
 - ITRF2014
 - DTRF2014
 - JTRF2014
 - JPL COMB2017
 - USNO final

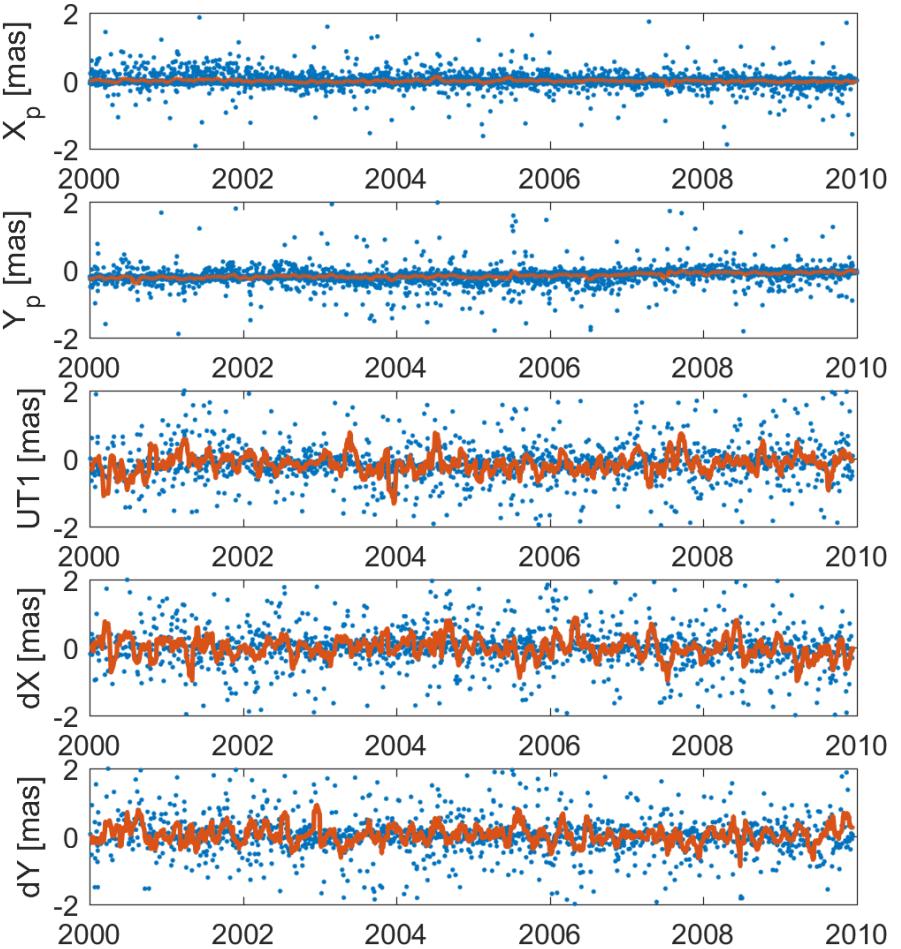
EOP comparison w.r.t. IERS C04 14

• EOP difference
— 30-day moving average

VLBI-only TRF/CRF solution



Combination TRF/CRF solution



EOP comparison w.r.t. IERS C04 14

- WRMS of EOP differences

WRMS [mas]	x_p	y_p	UT1	dX	dY
VLBI input	0.68	0.68	0.98	0.79	0.65
VLBI TRF/CRF	0.52	0.52	0.96	0.78	0.65
Comb TRF/CRF	0.12	0.21	0.86	0.78	0.64

EOP comparison w.r.t. IERS C04 14

- WRMS of EOP differences

WRMS [mas]	x_p	y_p	UT1	dX	dY
VLBI input	0.68	0.68	0.98	0.79	0.65
VLBI TRF/CRF	0.52	0.52	0.96	0.78	0.65
Comb TRF/CRF	0.12	0.21	0.86	0.78	0.64

Like current
ITRF

EOP comparison w.r.t. IERS C04 14

- WRMS of EOP differences

WRMS [mas]	x_p	y_p	UT1	dX	dY
VLBI input	0.68	0.68	0.98	0.79	0.65
VLBI TRF/CRF	0.52	0.52	0.96	0.78	0.65
Comb TRF/CRF	0.12	0.21	0.86	0.78	0.64

Like current
ICRF

EOP comparison w.r.t. IERS C04 14

- WRMS of EOP differences

WRMS [mas]	x_p	y_p	UT1	dX	dY
VLBI input	0.68	0.68	0.98	0.79	0.65
VLBI TRF/CRF	0.52	0.52	0.96	0.78	0.65
Comb TRF/CRF	0.12	0.21	0.86	0.78	0.64

Joint
TRF/CRF

Conclusions

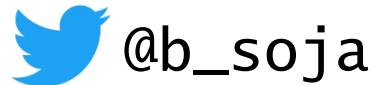
- EOP from ITRF and ICRF are inconsistent
- Joint determination for **consistent TRF/EOP/CRF**
 - Software SREF: time series approach
- Comparison with external EOP time series
- **Impact of joint determination:**

Tiny improvements in nutation
compared to ITRF-like solution

Large improvements in
polar motion and UT1
compared to ICRF-like
solution

Thanks for your attention!

bsoja@jpl.nasa.gov



Jet Propulsion Laboratory
California Institute of Technology

jpl.nasa.gov

Acknowledgements

B. Soja's research was supported by an appointment to the NASA Postdoctoral Program at the NASA Jet Propulsion Laboratory, administered by Universities Space Research Association under contract with NASA. U.S Government sponsorship acknowledged.